



Novel Nanonocomposite Membrane Structures For Hydrogen Separation

Product Line: Coal Fuels and Hydrogen, Transportation Fuels and Chemicals

Background/Description

Nearly 4 trillion scf of hydrogen are produced annually in the U.S. Production is expected to increase by about 10% per year due to growing needs for desulfurization by hydrotreatment of naphtha and diesel fuel. The emergence of fuel cell technologies, which require highly pure hydrogen, is also expected to generate a sizable market for hydrogen.

Most of the hydrogen is produced by steam reforming or partial oxidation of natural gas. These processes produce a gas mixture containing hydrogen and other gas contaminants (e.g., CO, CO₂, H₂O, H₂S, etc.) that must be removed before the hydrogen can be used in downstream processes. Unfortunately, the removal of these gaseous impurities cannot be performed economically at present.

The proposed research program would develop new classes of polymer/inorganic nanostructured membrane materials that exhibit "reverse selectivity," i.e., permeability to larger, more condensable molecules such as CO, CO₂, H₂O, and sulfur impurities than to smaller, less condensable molecules such as hydrogen. These membrane materials are heterophase block copolymers where one block (the soft block) is selected to have exceptional CO₂ (and other acid or polar gas) permeability and selectivity and the other (the hard block) provides mechanical strength and processing flexibility. Nanoscale inorganic fillers would be dispersed in these materials to further increase acid or polar gas permeability and acid or polar gas/H₂ selectivity. Several classes of polymer matrix materials and several types of fillers will be examined to identify optimum combinations. The sorption, diffusion, and transport properties of these novel materials, along with their morphology and physical properties, would be systematically characterized to establish a structure-morphology-property database to guide the synthesis of future generations of materials.

Goal

The goal of the project is to develop polymer/inorganic nanostructured membrane materials that exhibit "reverse selectivity" and improve hydrogen selectivity over current materials by at least 50 percent to produce pure hydrogen and carbon dioxide.

Benefits

Successful development of these nano-structured polymeric membranes is expected to improve hydrogen selectivity over current materials by 50%, resulting in enhanced hydrogen purity in the product stream, and nearly sequestration ready CO₂ as the permeate, depending upon the composition of raw syngas. This technology also has the potential to reduce the cost of hydrogen production by at least 5% over current conventional technologies.

Contact Information

Project Lead Organization

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Other Participants

Research Triangle Institute

Planned Project Funding

DOE □ \$200,000
Non-DOE \$ 0
Total □ \$200,000

UCR/HBCU Project Period of Performance

Sep. 2001 to Sep. 2004

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NETL Hydrogen Projects

Status as of December 2003:

- Prepared a series of filled membranes from two host polymeric materials, (i) Pebax, a polyether-polyamide block copolymer and (ii) poly(1-trimethylsilyl-1-propyne), and several commercially available inorganic nanoadditives at various filler concentrations (0-30 wt%).
- Synthesized crosslinked poly(ethylene oxide) samples and characterized the pure gas permeation and sorption properties of these crosslinked poly(ethylene oxide) samples.
- Evaluated the sorption and transport properties of the above polymers with a spectrum of penetrants to allow correlations between solubility and penetrant condensibility, diffusivity with penetrant size, and permeability condensibility and size.
- Produced a library of highly permeable, acid or polar gas-selective nanostructured polymer and inorganic hybrid membrane materials.

Schedule

FY 2004:

- Explore relationship between primary chemical structure and higher order morphological features of block polymers with their solubility, diffusivity, permeability and selectivity properties that regulate the separation of carbon dioxide and other related acid gases from mixtures with other gases.
- Interpret data from the above to correlate microstructure/property relationships with the rational tailoring of membrane materials that have efficacy in separating acid or polar gases.

Images/Diagrams

